TITLE

CLAMSHELL AND FORK-STYLE MATERIAL HANDLING APPARATUS

BACKGROUND OF THE INVENTION

The present invention relates in general to a pick and place robotic material handling unit for picking packages from a conveyor and dropping or placing the packages on a pallet, and more specifically, to a fork/clamshell material handling unit for palletizing bundles and containers from a conveyor.

Robotic systems for unloading of various types of packages from a conveyor line typically utilize either a clamshell gripper or a fork-type support member. A clamshell gripper is a compression type gripper where force is applied to two opposite sides of a container type package to secure the container during an unloading or loading process. Clamshell grippers do not support containers from the bottom and, therefore, typically require a high amount of pressure on the sides of the container to overcome a lack of support on the bottom side of the container. Damage can occur to products packaged within the container due to the forces exerted on the sides of the container especially in cases where soft containers (e.g. cardboard) or heat-shrunk bundles are being moved.

A fork-type support member typically picks up packages from the bottom similar to a spatula, supporting the package only from the bottom thereof with either one or an opposed pair of forks. The fork-type support member is commonly used with roller conveyor systems. The forks of the fork-type support member protrude into spaces between the rollers on a typical accumulation roller conveyor to engage and pickup the package from the bottom. The fork-type support member may include a top bar or pad to apply top pressure to secure the package to avoid tipping of the package during motion of the robotic system which is especially important when moving open top containers.

Fork-type support members have issues with meeting high production rates of bulk material due to slow actuation times of the mechanical linkages. Linear motion is commonly used as a maneuver in driving the forks under the package. Typical fork-type support members require that fork lengths cover nearly 80% of the package footprint to properly support the package during the unloading and loading process. Due to the nature, length, and necessary approach positions of using linear forks for loading packages, actual loading times can take up to two seconds. Furthermore, unloading placement times can be in excess of one

second due to the time needed for the linear forks to clear the bottom of the package. Additionally, because one set of grippers of a set length is not flexible to handle a wide range of package sizes, it is difficult to offer flexibility that a customer may desire in a material handling apparatus.

SUMMARY OF THE INVENTION

The present invention has the advantage of using a fork-type support member and a clam-shell gripping mechanism in an independent or a cooperating manner to efficiently and reliably unload packages from a conveyor system and place the packages on a pallet or the like.

In one aspect of the apparatus according to the present invention, a material handling apparatus includes a robotic arm adapted for vertical and horizontal movement. A clamshell gripping mechanism depending from the robotic arm is adapted to selectively engage the sides of a package. A fork-type loader also depends from the robotic arm. The fork-type loader is adapted to selectively support the package from one side of the bottom thereof. The clamshell gripping mechanism and the fork-type loader can be used in either an independent or a cooperating manner to support and move the package.

A material handling apparatus according to the present invention for moving packages between a conveyor and a destination location includes a robotic arm having a free end, a clamshell gripper means pivotally attached to the free end of the robotic arm and extending on opposite sides of a longitudinal axis thereof, and a first moving means attached to the free end of the robotic arm and to the clamshell gripper means for moving the clamshell gripper means between a clamped position and an unclamped position. A fork-type loader is attached to the free end of the robotic arm and is positioned adjacent one side of the clamshell gripper means. A second moving means is attached to the free end of the robotic arm and to the fork-type loader for moving the fork-type loader between a pick position and an open position.

A control means is connected to the first and second moving means for selectively operating the clamshell gripper means and the fork-type loader in independent and cooperative modes whereby the clamshell gripper means engages opposite sides of a package in the clamped position and the fork-type loader supports a bottom of the package in the pick position. An adjustable "hard stop" and/or a "soft stop" can be provided to selectively limit the swing of the clamshell gripper means and the fork-type loader when desirable. The

adjustable stop also can be applied to a case/bag gripper unit having opposed fork-type support members. An upper support pad and associated third moving means are attached to the free end of the robotic arm and the control means is connected to the third moving means for engaging the upper support pad with a top of the package.

BRIEF DESCRIPTION OF THE DRAWINGS

Fig. 1 is a side elevation view of a robotic material handling unit in accordance with the present invention for the handling of packages from a conveyor system;

Fig. 2 is a front elevation view of the fork/clamshell unit shown in Fig. 1 in a pickup ready position;

Fig. 3 is a view similar to Fig. 2 with the fork/clamshell unit in an unload ready position;

Fig. 4 is a block diagram of the control for the robotic material handling unit shown in Figs. 1-3;

Fig. 5 is a flowchart of a method in accordance with the present invention for operating the robotic material handling unit shown in Figs. 1-4 to unload packages from a conveyor system;

Fig. 6 is a block diagram of an adjustable stop used with the fork/clamshell unit according to the present invention; and

Fig. 7 is a front elevation view of a fork-type gripper unit showing the use of the adjustable stop.

DETAILED DESCRIPTION OF PREFERRED EMBODIMENTS

Referring now to the drawings, and particularly to Fig. 1, there is shown in side elevation a system according to the present invention for material handling a package **18**, such as a container, from a conveyor system. Although a "hard" sided container is shown in the drawings, the package **18** can be "soft" sided such as a plurality of bags wrapped in plastic shrink-wrap. A conveyor **16** comprises a plurality of plurality of spaced-apart (spaces **21**) transverse rollers **22** and extends longitudinally for transporting a plurality of packages **18** (only one is shown) from another location to a robotic material handling unit **10**. The conveyor **16** may be motorized **23**, or alternatively, the conveyor system may be a free-

spinning sloped roller conveyor where the packages **18** are gravitationally transported to an unloading station.

The robotic material handling unit **10** includes a robotic arm **11**, an overhead base unit **12**, and a fork/clamshell unit **14**. The robotic arm **11** can be a commercially available material handling robot such as the "M series" manufactured by Fanuc Robotics America, Inc. of Rochester Hills, Michigan. The overhead base unit **12** depends from a free end of the robotic arm **11** and mounts the downwardly extending fork/clamshell unit **14**. The robotic arm **11** connects to a controller **13** for controlling the movements of the arm **11** and the material handling operations of the fork/clamshell unit **14**. The unit **14** extends about a generally horizontal longitudinal axis **L** parallel to a path of travel of the packages **18** (from right to left in Fig. 1) on the conveyor **16**.

Fig. 2 shows the fork/clamshell unit **14** in more detail. A fork-type loader **15** depends from an underside of the base unit **12** at one side of a path of travel of the package **18**. A fork-type support member **20** of the fork-type loader **15** is coupled to a spaced pair of arms **19** that move in an arc-like direction (arrow **A**) between an open position (counterclockwise) and a pick position (clockwise). In the preferred embodiment, the arms **19** are generally S-shaped. Alternatively, the arms **19** may be of any suitable shape. A first or upper end of each arm **19** is coupled to a first end of a first pneumatic cylinder **30** by a first coupling member **48**. The first coupling member **48** includes a pin that allows pivotal movement between the first pneumatic cylinder **30** and the arms **19**. An opposite end of the first pneumatic cylinder **30** is securely fastened to a pneumatic cylinder support member **46** to stabilize the first pneumatic cylinder **30** during operation.

The arms **19** are pivotably secured at an intermediate point to a first vertical support member **40** by a first pivoting member **38**. The support member **40** is attached to and extends downwardly from the base unit **12**. The first pivoting member **38** allows the arms **19** to be pivotably driven by the first pneumatic cylinder **30** between the open and pick positions. The fork-type support member **20** is coupled to the lower ends of the arms **19** which all are connected together for simultaneous movement.

In the preferred embodiment, the fork-type support member **20** comprises a plurality of L-shaped forks (see Fig. 2). The L-shaped forks are preferably metal and have a metallic chrome finish. Alternatively, metal composites or alloys as well as other as other various finishes may be utilized. The L-shaped forks are spaced a predetermined distance apart from

one another corresponding to the spacing **21** of the rollers **22**. When in the pick position (Fig. 3) the fork-type support member **20** engages a bottom surface of the package **18**. Each individual fork extends into a corresponding one of the plurality of spaces **21** (shown in Fig. 1). This allows the L-shaped forks **20** to engage and lift the package **18** from the bottom without interference from the plurality of rollers **22**.

A clamshell gripper mechanism **17** of the fork/clamshell unit **14** comprises a first side support mechanical linkage **24** and a second side support mechanical linkage **25** disposed on opposite sides of the longitudinal axis **L** and the travel path for the package **18**. Each of the linkages **24** and **25** has a pair of downwardly extending arms. As shown in Fig. 1, the arms of the first linkage **24** are positioned between the arms **19**. A first or upper end of the first side support mechanical linkage **24** is coupled to a first end of a second pneumatic cylinder **31** (Fig. 4) similar to the first cylinder **30** by a second coupling member similar to the first coupling member **48**. The second cylinder **31** and second coupling member are hidden behind the first cylinder **19** and the first coupling member **48** in Fig. 2. An opposite end of the second pneumatic cylinder **31** is securely fastened to the pneumatic cylinder support member **46**. The first side support mechanical linkage **24** is pivotably secured to the first vertical support member **40** by the first pivoting member **38**. The first pivoting member **38**, disposed between the ends of each of the arms of the first side support linkage **24**, allows the second pneumatic cylinder **31** to pivotably drive the arms of the linkage **24** between the open or unclamped position and the pick or clamped position along an arc **B**.

Likewise, a first or upper end of the second side support mechanical linkage **25** is coupled to a first end of a third pneumatic cylinder **32** by a third coupling member **49**. The second linkage **25** is pivotably secured to a second vertical support member **41** by a second pivoting member **39** between the opposite ends of a pair of arms of the second linkage **25**. The second pivoting member **39** allows the third pneumatic cylinder **32** to pivotably drive the second linkage **25** between the unclamped and clamped positions along an arc **C**.

A lower end of each of the arms of the first linkage **24** is securely fastened to a first side support plate **26**. Likewise, a lower end of each of the arms of the second linkage **25** is securely fastened to a second side support plate **27**. The side support plates **26** and **27** are elongated structural members extending a predetermined length and width to engage opposite sides of the package **18**. In the preferred embodiment the side support plates **26** and **27** are rectangular. The bottom portions of the side support plates **26** and **27** each include a plurality

of forks 36 and 37 respectively. The forks 36 and 37 extend generally vertically and are spaced apart. As the side support plates 26 and 27 engage the respective sides of the package 18, each individual fork of the side support plates 26 and 27 displaces within a corresponding one of the spaces 21 (shown in Fig. 1) of the conveyor 16 without interference from the plurality of rollers 22. This allows for increased speed when clamping the package 18 since the plurality of forks 36 and 37, and the spaces therebetween, eliminate a potential interference condition with the plurality of rollers 22. Otherwise tight tolerances and slow maneuvering would be required for transitioning the side support plates against the sides of the package 18 to fully engage the package 18 directly above the plurality of rollers 22. As the side support plates 26 and 27 transition between the unclamped and clamped position, the side support plates 26 and 27 contact opposite sides of the package 18 and apply a low predetermined compression force to the package 18. The low predetermined compression force stabilizes the package 18 while the package 18 is being unloaded from the conveyor 16 and transferred to a desired location such as a shipping pallet (not shown).

The stabilization attained by utilizing the first and second side support mechanical linkages 24 and 25 permits less than 50% of a footprint (i.e., bottom surface) of the package 18 to be supported by the fork-type support member 20. This allows for flexibility in handling a wide range of package sizes. With the combined use of the fork-type loader 15 and the clamshell gripper mechanism 17, sufficient material handling support is provided so that typical heat shrink bundles can be handled reliably and efficiently even when the heat shrink is loosely wrapped.

Furthermore, the present invention transitions the fork-type loader 15 between the open and pick positions using a swing out arc-like motion as opposed to a drop down and linear slide motion. The actuation time to transition between the unloaded and loaded positions is less than 0.25 seconds. This fast actuation time allows for containers or bundles to be loaded and unloaded at a much higher rate than conventional pick and place robotic units, and as a result, higher production rates are achieved.

Additionally, an upper support pad 35 may be utilized to provide a downward force to further secure the package 18 during motion of the robotic material handling unit 10. A fourth pneumatic cylinder 34 is attached to the base unit 12 and is used to drive the upper support pad 35 against a top surface of the package 18. The upper support pad 35 is positioned vertically inline with a portion of the fork-type support member 20 in the pick

position (Fig. 3) so that a compression force may be applied to a top and bottom portion of the package **18** that is disposed between the upper support pad **35** and the fork-type support member **20**. The cylinder **34** is controlled by the controller **13** to raise the pad **35** to a disengaged position (Fig. 2) and lower the pad to an engaged position (Fig. 3). The support member **20** and the pad **35** cooperate to reduce the amount of pressure required to be applied by the plates **26** and **27** in order to stabilize the package **18**.

Fig. 3 illustrates the robotic material handling unit **10** in the clamped pick position. The second pneumatic cylinder **31** (not shown) and the third pneumatic cylinder **32** are actuated to drive the first and second side support linkages **24** and **25** to the clamped position. The first and second side support plates **26** and **27** are clamped against opposing sides of the package **18**. At approximately the same time, the arms **19** are driven to the loaded position by the first pneumatic cylinder **30**. The fork-type support member **20** engages a bottom surface of the package **18**. The upper support pad **35** is driven into contact with the upper surface of the package **18** by the fourth cylinder **34** to further stabilize the package **18**. The package is then picked up from the conveyor **16** and positioned over a drop location by movement of the robotic arm **11**.

At a designated placement location the picking process is reversed to drop the package **18** onto, for example, a pallet. The articulating arms **19** are driven to the open position by the first pneumatic cylinder **30**. The fork-type support member **20** is retracted in the arc-like motion **A** from the bottom surface of the package **18**. The first side support mechanical linkage **24** is opened slightly to relieve pressure from the sides of the package **18**. The upper support pad **35** is then retracted. The material handling unit is upwardly displaced by the robotic arm **11** to clear the package **18**. Both side support linkages **24** and **25** are then fully retracted to the unclamped positions as the robotic material handling unit **10** is returned to the position over the conveyor **16** shown in Figs. 1 and 2 to pick the next package.

Fig. 4 is a block diagram showing the control system for the robotic material-handing unit **10**. The controller **13** is connected to the robotic arm **11** to selectively control the movement of the base unit **12** and attached material handling unit **14** between the conveyor **16** and a destination such as a pallet (not shown). The controller **13** is connected to each of the first **30**, second **31**, third **32** and fourth **34** pneumatic cylinders to actuate the fork-type loader **15**, the first linkage **24**, the second linkage **25** and the pad **35** respectively.

In a second preferred embodiment of the apparatus and method of operation, a servo drive unit **42** (Fig. 4) connected to the controller **13** can be utilized if packages of different known sizes are to be unloaded from the conveyor **16**. Typically, clamshell gripper **17** is configured to clamp to a predetermined position to pick up uniform packages of the same dimensions. If known different width packages are transported along the conveyor **16**, the robotic material handling unit would need to adjust the spacing between the side support plates **26** and **27** to accommodate the width of each package. If the width of each package is known as it transitions to the pick position along the conveyor **16**, the servo drive unit **42** could adjust the first side support linkage **24** and first side support plate **26** accordingly to accommodate each known different width package.

To adjust the first side support mechanical linkage **24** laterally, the servo drive unit **42** is coupled to a linear guide mount (not shown). The first side support mechanical linkage **24** is also coupled to the linear guide mount. As the servo drive unit **42** drives the linear guide mount laterally (transverse to the longitudinal axis **L**), the first linkage **24** is also driven laterally either toward or away from the package **18** depending upon the package width relative to the width of the previous package. To pick a package, both of the side support mechanical linkages **24** and **25** and the fork-style support member **20** transition to the clamping and pick positions. As the first side support mechanical linkage **24** moves in an arc-like manner to the clamp position, the servo drive unit **42** simultaneously moves the first side support linkage **24** laterally to adjust to the known package width. A soft float may further be utilized with the servo drive **42**.. A soft float is incorporated into the software of the controller **13** of the robotic material handling unit **10**. As the first side support mechanical linkage **24** transitions to the clamped position, the controller **13** senses the pressure exerted on the side of the package **18**. To maintain a small amount of force on the sides of the package **18** so as only to stabilize the package **18**, the controller **13** adjusts the servo drive unit **42** accordingly to apply a predetermined amount of compression force to the package **18** as required to maintain stabilization.

The servo drive unit **42** may further be used in unclamping the package **18** by laterally relieving pressure from the side of the package **18** engaged against the first side support mechanical linkage **24**. After the fork-style loader **20** is retracted from the pick position toward the open position, the servo drive unit **42** laterally drives the first side support mechanical linkage **24** via the linear guide mount partially away from the package **18** to

relieve the compression force. This allows the package **18** to drop vertically to the destination location without any tilting of the package. Both side support mechanical linkages **24** and **25** thereafter are fully retracted to the open positions.

Fig. 5 illustrates a method for unloading a package from a conveyor system. In a step **50**, the robotic material handling unit **10** is vertically positioned over the conveyor system. The conveyor system transports a plurality of packages **18** in sequence to an unloading station where the robotic material handling unit **10** is disposed vertically above the conveyor **16**. In a step **52**, the second **31** and third **32** pneumatic cylinders are actuated to drive the first **24** and second **25** support member linkages in an arc-like motion to the clamped position. As the support member linkages **24** and **25** are driven to the clamped position, the first **26** and second **27** side support plates will apply the low predetermined compression force to the opposing sides of the package **18**. Simultaneously, the first pneumatic cylinder **30** drives the arms **19** into the pick position. The fork-type support member **15** will move in the arc-like motion **A** from the open position to the pick position and engage against a bottom surface of the package **18**. Each of the L-shaped forks of the support member **20** will transition into the corresponding space **21** between the rollers **22** to engage the bottom surface of the package **18**. In a step **54**, the top support pad **35** is lowered to engage against a top surface of the package **18** to further stabilize the package. In a step **56**, the robotic material handling unit **10** is vertically raised to pick the package **18** from the conveyor **16**. In a step **58**, the robotic material handling unit **10** transitions to a dedicated location for placement of the package **18**. In a step **60**, the first pneumatic cylinder **30** is actuated to drive the fork-type support member **15** to the open position. The fork-type support member **15** will be disengaged from the bottom surface of the package **18** with the arc-like motion **A** to the open position. In a step **62**, the second pneumatic cylinder **31** is actuated to retract the first side support member **24** a predetermined distance from the side of the package **18** so that the first side support plate **26** slightly relieves pressure on the side of the package allowing the package to drop. In a step **64**, the robotic material handling unit **10** is displaced upwardly to clear the package **18**. In a step **66**, the robotic material handling unit **10** is returned to the package pickup location over the conveyor **16** package picking station. During the transition from the drop or unloading location to the package pickup location, the side support members **26** and **27** are returned to the unclamped positions.

In some applications, it is desirable to limit the arcuate travel of the arm **19** and/or the linkages **24** and **25** to less than full travel. For example, two of the robotic material handing units **10** can be positioned side-by-side to unload two adjacent conveyors. By limiting the outward swing of the arm **19** and/or the linkages **24** and **25** to, for example, approximately 15°, the distance between the conveyors and the units **10** can be minimized for space savings. However, this swing limitation may cause interference with previously stacked packages when attempting to stack another package.

In Fig. 6, there is shown an adjustable stop system for use with the robotic material handing units **10**. The controller **13** is connected to control a linkage actuator **70** which can be any of the pneumatic cylinders **30**, **31** and **32**. The linkage actuator **70** is connected a linkage **72** which can be the one of the arm **19** and the linkages **24** and **25** corresponding to each of the pneumatic cylinders **30**, **31** and **32**. A linkage position sensor **74** is connected to the controller **13** for sensing a position of the linkage **72** and providing that position data to the controller. In this manner, the controller **13** can control the linkage actuator **70** to stop the swing of the linkage **72** at any predetermined "stop" position including different positions for picking up and dropping the package. As an alternative to or combined with the sensor **74**, the linkage actuator **70** can provide position feedback to the controller **13**. This method of control provides an adjustable "soft stop" since no mechanical stop engages the linkage **72**.

The controller **13** can be connected to control a stop actuator **76** which is connected a mechanical stop **78** for engaging one of the one of the arm **19** and the linkages **24** and **25**. A stop position sensor **80** is connected to the controller **13** for sensing a position of the stop **78** and providing that position data to the controller. In this manner, the controller **13** can control the stop actuator **76** to position the stop **78** at any predetermined "stop" position including different positions for picking up and dropping the package. As an alternative to or combined with the sensor **80**, the stop actuator **76** can provide position feedback to the controller **13**. This method of control provides a "hard stop" since there is a mechanical stop engaging the linkage **72**. The linkage position sensor **74** can be used to confirm the position of the linkage **72** to the controller **13**.

The adjustable stop also can be utilized with a robotic material handling unit **90** of the conventional case/bag gripper type. The unit **90** includes a robotic arm **91**, an overhead base unit **92**, and a case/bag gripper unit **94**. The robotic arm **91** can be like the arm **11** shown in Figs. 1-4. The overhead base unit **92** depends from a free end of the robotic arm **91** and

mounts the downwardly extending case/bag gripper unit **94**. The robotic arm **91** connects to a controller **93**, similar to the controller **13** of Figs. 1 and 4, for controlling the movements of the arm **91** and the material handling operations of the case/bag gripper unit **94**.

The unit **94** includes a pair of pivot points **97a** and **97b** at opposite sides of a path of travel of a package **98** such as a case or a bag. Each arm of a pair of associated arms **99a, 99b** has an upper end rotatably attached to the respective one of the pivot points **97a, 97b** for movement in an arc-like direction (arrows D and E respectively) between an open position (counterclockwise) and a pick position (clockwise). An associated fork-type support member **100a, 100b** is coupled to lower ends of the arms **99a, 99b** respectively. In the preferred embodiment, the fork-type support member **100a, 100b** comprises a plurality of L-shaped forks (see member **20** in Fig. 2).

The arms **99a, 99b** are coupled to the actuator **96** which preferably can be a pneumatic cylinder. Under the control of the controller **93**, the arms can pivot to a maximum open position of approximately 100° as illustrated by the arm **99b** in Fig. 7 to minimize interference with packages **98** already present when palletizing. However, one or both of the arms can be limited by the stop **78** (Fig. 6) to any selected limited open position. For example, the arm **99a** is shown in a stop-limited open position at approximately 15° from vertical.

In accordance with the provisions of the patent statutes, the present invention has been described in what is considered to represent its preferred embodiment. However, it should be noted that the invention can be practiced otherwise than as specifically illustrated and described without departing from its spirit or scope.